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Optimal Dates for Collection of Conifer Seed in Central Newfoundland

W.J. Curran , P. Tricco and J. Peter Hall

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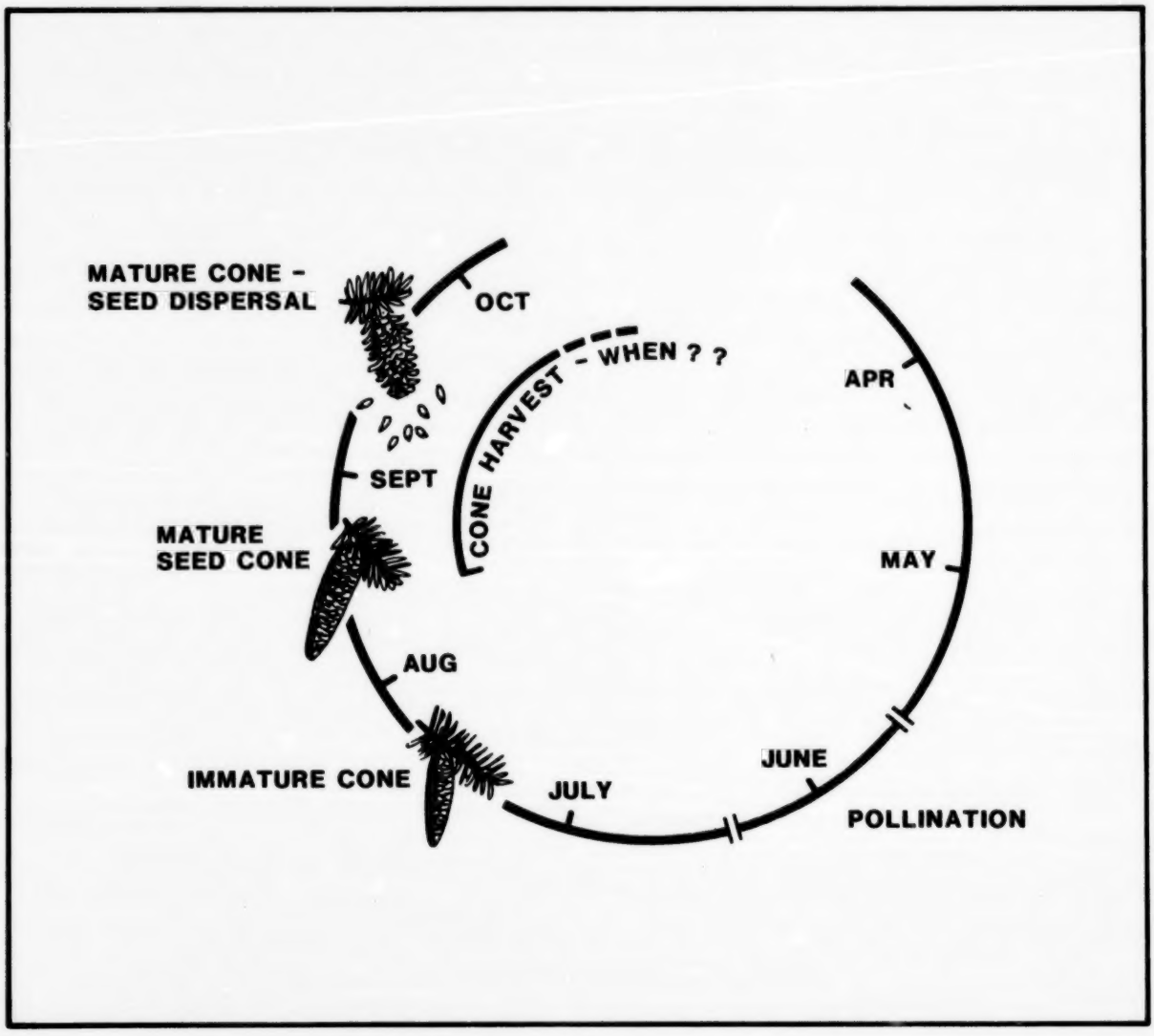

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OPTIMAL DATES FOR COLLECTION OF CONIFER SEED IN CENTRAL NEWFOUNDLAND

by W.J. Curran, P. Tricco and J. Peter Hall

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ABSTRACT

The increased demand for seed for use in reforestation in Newfoundland has focused attention on increasing the productivity of programs of seed collection. One method is to begin harvesting cones early to reduce losses to predators. Various dates of collection were examined for black spruce, white spruce and tamarack in central Newfoundland. Based on germination percentage and germination capacity it was concluded that harvesting of cone crops could begin by late August. White spruce seed matured the earliest of the three.

RÉSUMÉ

L'accroissement de la demande de graines à des fins de reboisement à Terre-Neuve a attiré l'attention sur les moyens d'accroître la productivité des programmes de récolte des graines. L'un de ces moyens est de commencer tôt la récolte des cônes afin de réduire les pertes causées par les ravageurs. Diverses dates de récolte ont été examinées pour l'épinette noire, l'épinette blanche et le mélèze laricin dans le centre de Terre-Neuve. On a conclu d'après les pourcentages de germination et le pouvoir germinatif, que la récolte des cônes pourrait commencer à la fin d'août. Ce sont les graines de l'épinette blanche qui, parmi les trois espèces étudiées, parviennent à maturité le plus tôt.

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OPTIMAL DATES FOR COLLECTION OF CONIFER SEED IN CENTRAL NEWFOUNDLAND

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INTRODUCTION

Black spruce (Picea mariana (Mill.) B.S.P.) is primarily used as a seed source for reforestation in Newfoundland and Labrador. However interest in white spruce (Picea glauca (Moench) Voss) is increasing and the use of tamarack (Larix laricina (Du Roi) K. Koch) seems promising (Hall 1981a). Most reforestation will consist of planting bareroot and container stock; however, some direct seeding is planned. It has been estimated that to reforest 1000 hectares of forest land to black spruce using bareroot seedlings would require 9.6 kilograms of seed (six hectolitres of cones); container stock would require 4.8 kg of seed (three hectolitres of cones), and direct seeding would require 176.4 kilograms of seed (110 hectolitres of cones) (Hall 1981a).

Seed for reforestation is obtained by the Department of Forest Resources and Lands (DFRL). Cones are collected from mid-September to November. Collecting at these late dates reduces worker productivity due to inclement weather and increases cone losses to small mammals such as the introduced red squirrel (Tamiasciurus hudsonicus Erxleben). Also seed losses occur in white spruce and tamarack from opening of mature cones.

There is a need to determine the earliest cone collection dates to both optimize seed yields and reduce the problems associated with late collections. If current collection dates could be advanced by a few weeks many of these problems can be avoided (Hall 1981a).

This paper presents the results of a study designed to determine the earliest date which cones of black spruce, white spruce and tamarack could be collected.

METHODS

Sample Trees

Eight trees of each species bearing over 100 cones each were selected in the North Pond Forest Experimental Area (48°42'N, 54°30-38'W) part of Forest Section B.28b - Grand Falls, of the Boreal Forest Region (Rowe 1972). The black spruce and tamarack were located on a burned cutover (elevation 90 m) and were approximately 20 years old. All trees were open-grown and spaced approximately 20 m apart. The white spruce trees were selected from the local Newfoundland provenance in the Great Lakes - St. Lawrence white spruce provenance plantation (elevation 150 m). Age of the white spruce trees averaged 25 years (Hall 1986).

Seven cone collections were made between August 3 and September 21, 1984 for white spruce and tamarack, and eight collections of black spruce, ending on October 18, 1984. Cones were placed in paper bags and stored at 2-3°C within 1-2 days of collection.

Seed Extraction

All cones were removed from cold storage on the same day and placed on cone drying trays under heated (20-23°C), well ventilated (70% R.H.) conditions. The white spruce cones opened readily and the seed was

extracted and cleaned by standard procedures using shakers and blowers (Anon. 1976). Black spruce cones were soaked in warm water (30°C) for one hour, then heated at 49°C for 24 hours after which extraction was by standard procedures. Tamarack cones opened but shaking failed to release the seeds. Therefore, seeds were removed manually using tweezers and probes. All seed was weighed, counted and stored in plastic vials at 2-3°C for a period of two months until tested.

Germination Tests

White spruce and tamarack seed were germinated according to ISTA procedures in a seed germinator at 27°C during the day, 20°C at night, 90% R.H. with 16 hours daylight for 28 days (Anon. 1976). The black spruce seed was germinated in a greenhouse under similar conditions. The tests were designed as a randomized complete block with four replicates of 50 seeds each (Steel and Torrie 1960). Seedlots from some collection dates were smaller and in these fewer than 50 seeds were used. After germination was complete the ungerminated seed were cut and the numbers of filled seed determined.

A malfunction in the greenhouse resulted in all black spruce seed being killed after eight days. A later series of tests was conducted in the seed germinator but there was insufficient seed for the full range of dates and only five of the eight dates were replicated.

The white spruce seed was separated into two groups, one of which was stratified at 2-3°C for 28 days. The two lots of seed were germinated under similar conditions but there was no difference in percentage germination or germination capacity between the two.

Data Analysis

Data were analysed according to standard analysis of variance (ANOVA) techniques and means were compared using Duncan's New Multiple Range Test (Steel and Torrie 1960). Percentage data were analysed following arcsin transformation and using the actual data. Both analyses were of equal efficiency and therefore the ANOVA based on the actual data is included.

RESULTS AND DISCUSSION

Percentage germination is the proportion of seed which germinates; germination capacity is the proportion of filled seed which germinates.

Percent germination was significantly different for dates, trees and interaction between dates and trees for white spruce and tamarack. Tree to tree variation in black spruce was not significantly different (Appendix I). This may reflect naturally low levels of inter-tree variation in black spruce as compared to white spruce and tamarack. Since percentage germination is a reflection of the proportion of fertilized ovules an alternative explanation is that fertilization occurred more evenly throughout the crowns in black spruce compared to the other species. This explanation is given further weight because the black spruce trees came from a closed stand covering several hectares whereas the white spruce and tamarack trees were scattered and less likely to be exposed to a large pollen cloud.

Germination capacity was significantly different among dates and dates x trees (interaction) in all species. While there is some tree to tree variability (Figures 1 to 3), germination differences among trees are not significant for any species. This indicates that seed on different trees within the same species matures at the same time. Differences in seed germination capacity were highly significant among dates (Appendix I). This suggests that date of collection is critical for seed maturity. Cone and seed size, and seed yields were similar for all dates and corresponded well with yields of these species elsewhere in Newfoundland (Table 1) (Hall unpub. data, Hall 1981b).

Collections made in early August consistently yielded fewer viable seeds per cone than those made on 20 August or later (white spruce, tamarack) or on 30 August or later (black spruce) (Table 1). (No data were available for black spruce on 20 August.) This change over time in seed yield was more pronounced in black spruce and tamarack than in white spruce. At the earliest dates about one-third of the white spruce seed germinated indicating that white spruce seed matures earlier than black spruce or tamarack. One anomaly in the trend of increased seed viability is the lowered viability of the 6 September collection for white spruce and tamarack and a lowered viability later in September in black spruce. (Cones of the three species were treated similarly during collection and processing.) There is no obvious explanation for this but a common feature of the three species is that this drop in viability occurred 101-106 days after pollination in the three species. The drop in germinability may be the result of chemical changes as the seed

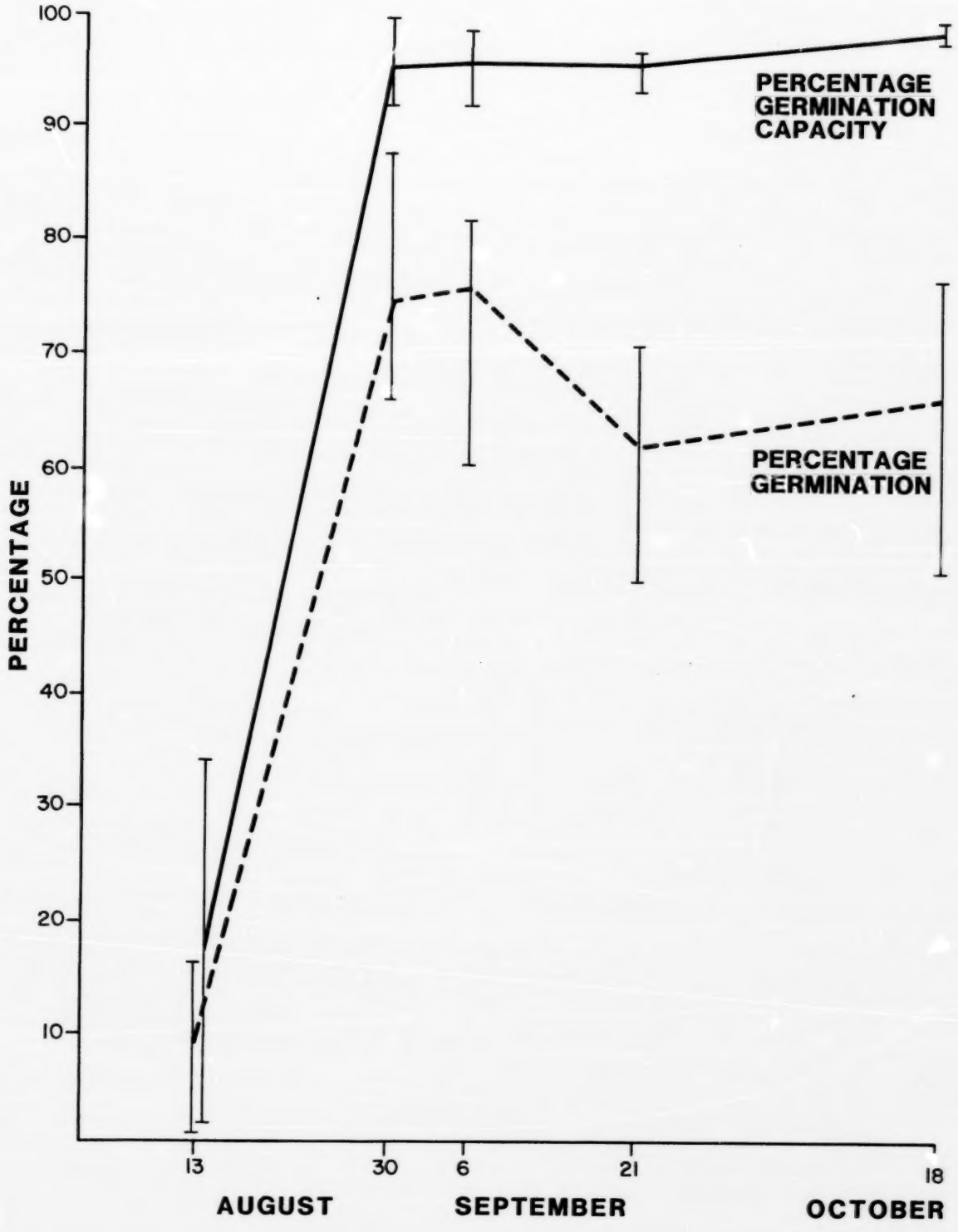

FIGURE 1. PERCENTAGE GERMINATION AND GERMINATION CAPACITY OF BLACK SPRUCE DURING AUGUST - OCTOBER. VERTICAL LINES INDICATE RANGE OF DATA.

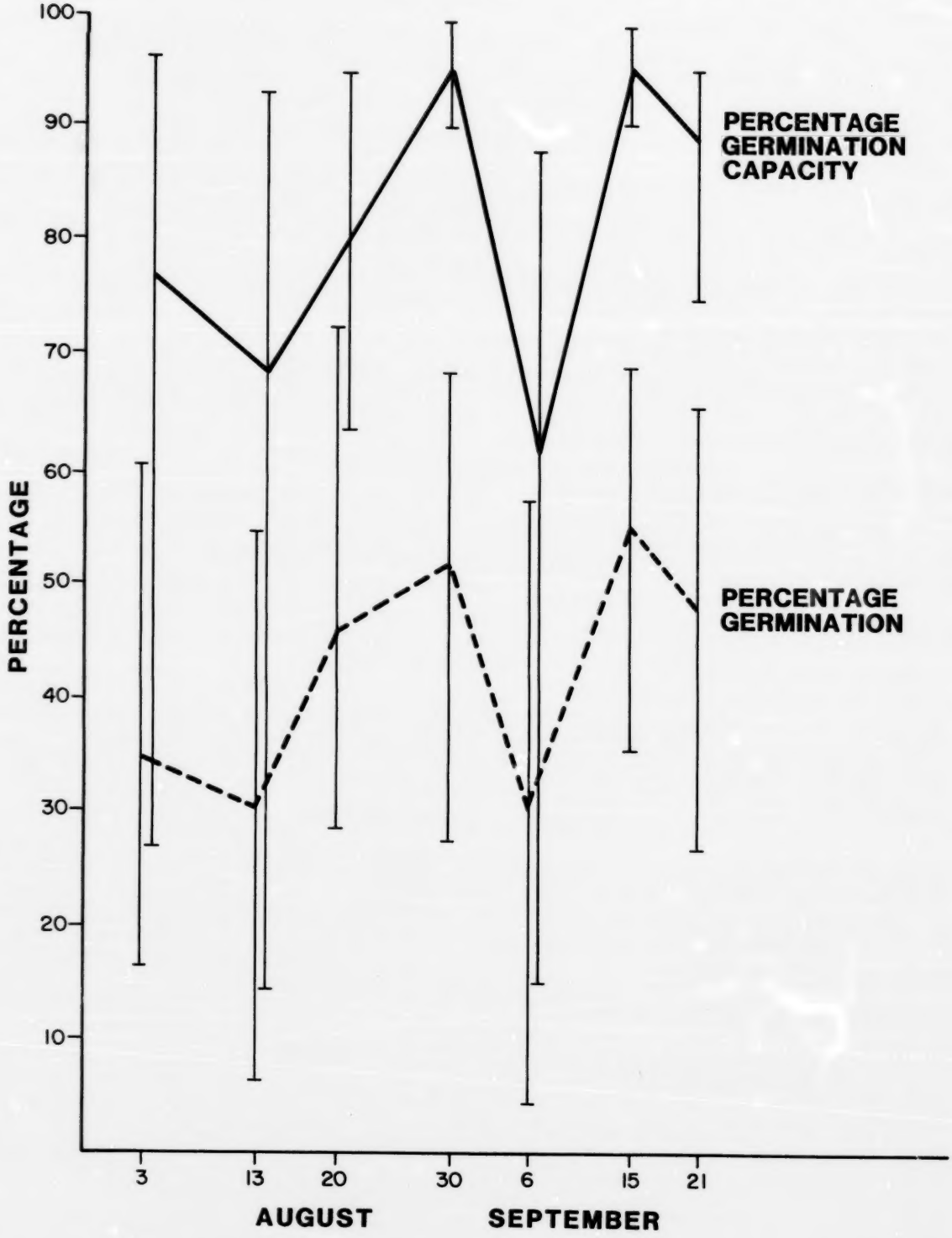

FIGURE 2. PERCENTAGE GERMINATION AND GERMINATION CAPACITY OF WHITE SPRUCE DURING AUGUST - SEPTEMBER. VERTICAL LINES INDICATE RANGE OF DATA.

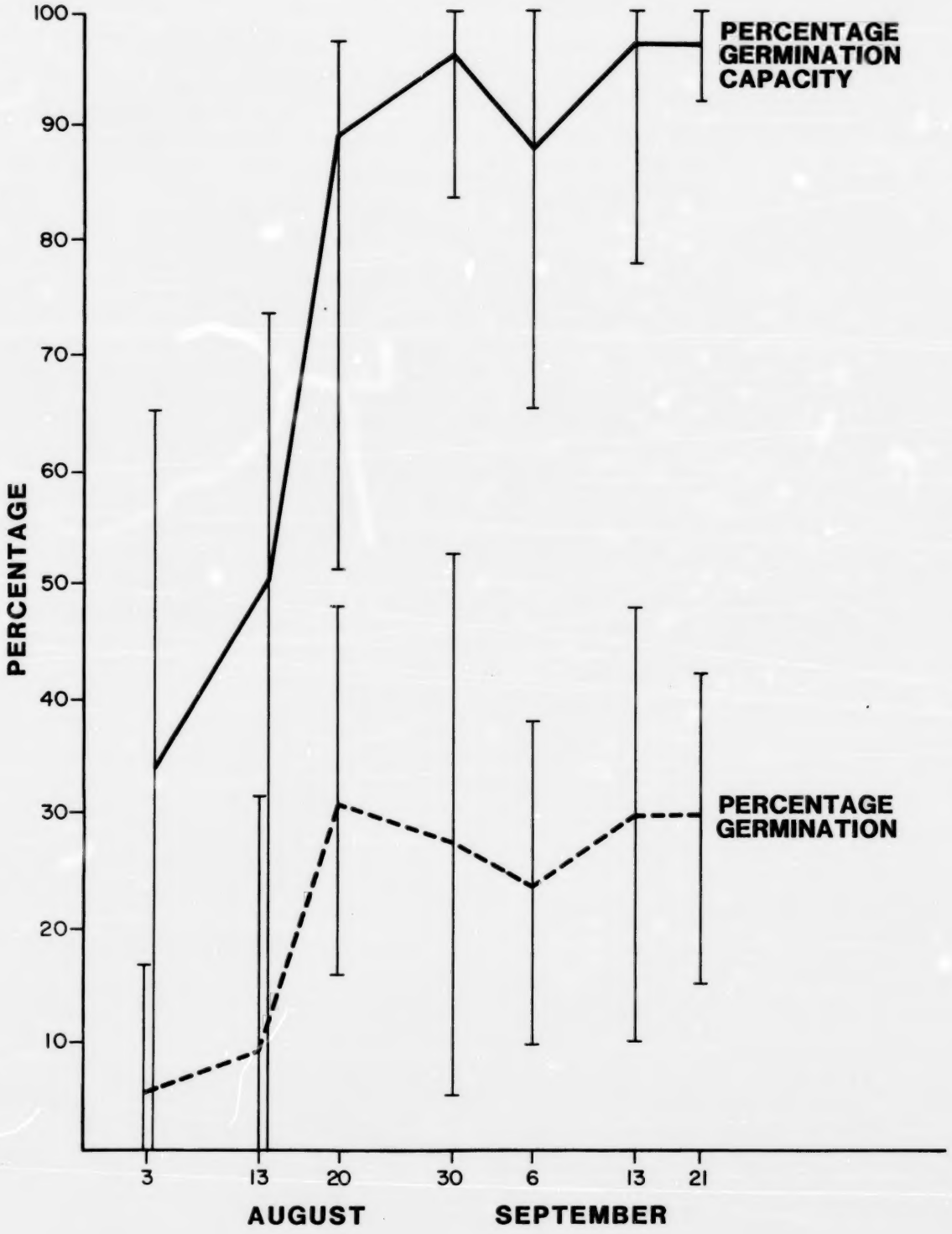

FIGURE 3. PERCENTAGE GERMINATION AND GERMINATION CAPACITY FOR TAMARACK DURING AUGUST - SEPTEMBER. VERTICAL LINES INDICATE RANGE OF DATA.

Table 1. Seed yield, percentage germination and germinative capacity of seed collected on various dates.

Date collected	Avg. cone wt. (g)	1000 Seed wt. (g)	Seed Per Cone			Percentage germination	Germination capacity
			Total	Filled	Viable		
Black Spruce							
13 August	1.54	1.15	58.8	30.3	5.3	9.0a[1]	18.0a
30 August	1.58	1.21	44.0	34.5	33.0	75.0b	95.5b
6 September	1.64	1.25	47.5	37.7	36.1	76.0b	95.8b
21 September	1.65	1.06	51.6	33.4	32.0	62.0b	95.8b
18 October	1.74	1.11	50.8	34.0	33.7	66.3b	98.9b
White Spruce							
3 August	1.02	1.26	74.9	33.8	26.0	34.8a	77.1bc
13 August	1.14	1.69	83.9	36.7	25.3	30.2a	68.5ab
20 August	1.21	1.69	82.6	47.6	38.0	46.0b	79.8bcd
30 August	1.16	1.75	82.4	45.0	42.8	51.9b	95.1d
6 September	1.19	1.80	88.3	43.7	26.8	30.4a	61.4a
15 September	1.08	1.74	79.2	46.2	44.0	55.5b	95.1d
21 September	1.01	1.65	79.3	43.1	37.7	47.5b	88.4cd
Tamarack							
3 August	0.21	1.55	10.4	1.5	0.5	4.9a	33.3a
13 August	0.21	1.68	11.8	2.0	1.0	8.5a	49.8a
20 August	0.22	1.70	14.2	4.9	4.3	30.5b	88.7b
30 August	0.18	1.53	11.6	3.3	3.1	26.9b	95.6b
6 September	0.20	1.53	12.5	3.3	2.9	22.8b	87.5b
15 September	0.19	1.58	12.0	3.6	3.5	28.9b	96.7b
21 September	0.18	1.51	11.5	3.5	3.4	29.2b	96.5b

[1]Means of percentage germination and germination capacity followed by the same letter are not significantly different from each other at probability level 0.95.

enters dormancy. Alternatively there may be late-feeding insects such as the fir coneworm or spruce seedworm which destroy some of the seed.

Several researchers have used Cumulative Degree Days (CDD), number of days x temperature above 5°C, as a predictor of seed maturity (Smith 1983, Winston and Haddon 1981, Zasada 1973). They found good correlations between CDD and seed maturity as measured by seed germination when the method was used in areas of continental climate. In this study the CDD was compared to the various collection dates tested. Since it was not possible to monitor CDD on the study site the CDD for Gander International Airport (40 km north of the study site) was used. White spruce and tamarack seed mature by 20 August when CDD (for 1984) is 955 and black spruce seed matures by 30 August after 1050 CDD (Table 2). Smith (1983) suggested white spruce could be collected in the Maritimes after 1200 CDD and Winston and Haddon (1981) suggested for white spruce in Ontario that 1222 and 1275 CDD were needed to ripen seed. As a result of the cooler climate in Newfoundland the CDD during the growing season would be less than that for the Maritimes or Ontario. The suggested figure of 955 CDD for white spruce compares well with other studies (Smith 1983, Winston and Haddon 1981).

Table 2. Cumulative Degree Days at Gander 1982-85 up to 20 and 30 August.

	CDD 1982-1985				Mean
	1982	1983	1984	1985	1982-85
CDD up to Aug. 20	754.7	963.5	954.8	890.6	847.0
CDD up to Aug. 30	841.1	1023.8	1050.5	967.2	960.0

The growing season in 1984 was warmer than usual, over 100 degree-days above normal by 20 August and 90 degree-days above average by 30 August (Table 1). These warmer temperature sums of 1984 undoubtably advanced the seed ripening process. Remrod and Alfjorden (1973) suggested that climate during different years affects the ripening process, with high temperature sums leading to rapid seed maturity, and low temperature sums delaying or preventing maturity. The high CDD summaries for 1984 may have caused the seed in this study to ripen earlier than in normal years. Therefore, the collection dates, August 20 and 30, may not apply to other years. Zasada (1973) stated that degree-day summations provide a quantitative measure of the progress of the growing season and if used over a number of years, should be a reliable indicator of seed ripeness.

Storage of cones following collection is critical to the maturation of seed. In this study cones were placed in cold storage (2-3°C) as soon as possible after collection. In commercial operations the cones are usually shed stored under dry, cool (10°C) well ventilated conditions; storage under such conditions increases the seed germinability (Crossley 1953). Seeds in cones that have been picked before they are "mature" may continue to draw sustenance from the cone and continue development. Rediske (1969) in a study on Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) found that cones collected on 23 July increased seed germinability from 1% at time of picking to 53% after two weeks of storage in open sheds. In Sweden, Remrod and Alfjorden (1973) showed

increased viability of Scots pine (Pinus silvestris L.) seed after storage at 10°C in well ventilated conditions. Winston and Haddon (1981) found that white spruce cones collected as early as 1 August yielded seed of high germinability if the cones were stored for 12 weeks at 5°C and 75-90% R.H. Zasada (1973) in a study of white spruce in Alaska found outdoor storage of cones under well ventilated conditions (average daily maximum 17°C, minimum 8°C) also gave high germinability in seed collected as early as 22 July. It is apparent that seed germinability can be maintained and enhanced if cones are picked early and stored properly.

Cone losses to squirrels has been observed over the last 7-8 years when the population levels rose dramatically. In a study on black spruce in western Newfoundland, squirrels had harvested 33% of the cones by 10 September and 75% by 30 October (West and Durling 1986). In another study on black spruce in the North Pond Forest Experimental Area, squirrels had harvested 27-30% of the cone crop by 30 August.[1] No data are available on cone losses to squirrels in white spruce and tamarack.

In poor cone crop years and if demand for seed is great, cones should be harvested as early as possible to minimize losses to squirrels. Our study indicates 20 August as the optimal date for collection of white spruce. Stratification and proper storage techniques should be used to compensate for the normal maturation process.

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[1]R. West, personal communication.

Similarly, black spruce collections should begin by at least 30 August to minimize squirrel losses. Proper cone storage will enhance and maintain the germinability of early collections.

CONCLUSIONS

Recommended cone collection dates are 20 August for white spruce and tamarack and 30 August for black spruce. It should be noted, however, that seed maturation dates will vary from year to year depending on climatic conditions. This variation can be compensated for by proper cone storage which allows seed maturation to continue after collection. Early collections will reduce cone losses to squirrels and prevent seed losses from natural seed dissemination. Further studies are necessary to correlate seed maturity with cumulative degree day summaries.

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Appendix I. Analysis of variance of percentage germination and germination capacity of black spruce, white spruce and tamarack.

		Percentage Germination			Germination Capacity		
Source	dF	SS	MS	F[1]	SS	MS	F
Black Spruce							
Dates	4	48667	12167	36.87***	74994	18748	78.77***
Trees	3	1678	509	1.54n.s.	348	116	0.49n.s.
Dates x Trees	12	3964	330	2.97***	2855	238	3.70***
Error	60	6631	111		3772	63	
Total	79	60940			81968		
White Spruce							
Dates	6	20940	3490	5.87***	36161	6027	5.58***
Trees	7	20129	2876	4.83***	10226	1461	1.35n.s.
Dates x Trees	42	24995	595	7.97***	45378	1080	10.91***
Error	168	12547	75		16606	99	
Total	223	78611			108371		
Tamarack							
Dates	6	20726	3454	10.37***	20126	3354	32.56***
Trees	7	13064	1866	5.60***	988	141	1.37n.s.
Dates x Trees	42	14000	333	3.62***	4310	103	4.12***
Error	168	15444	92		4152	25	
Total	223	63234			29576		

[1]***Statistically significant at P = 0.995.